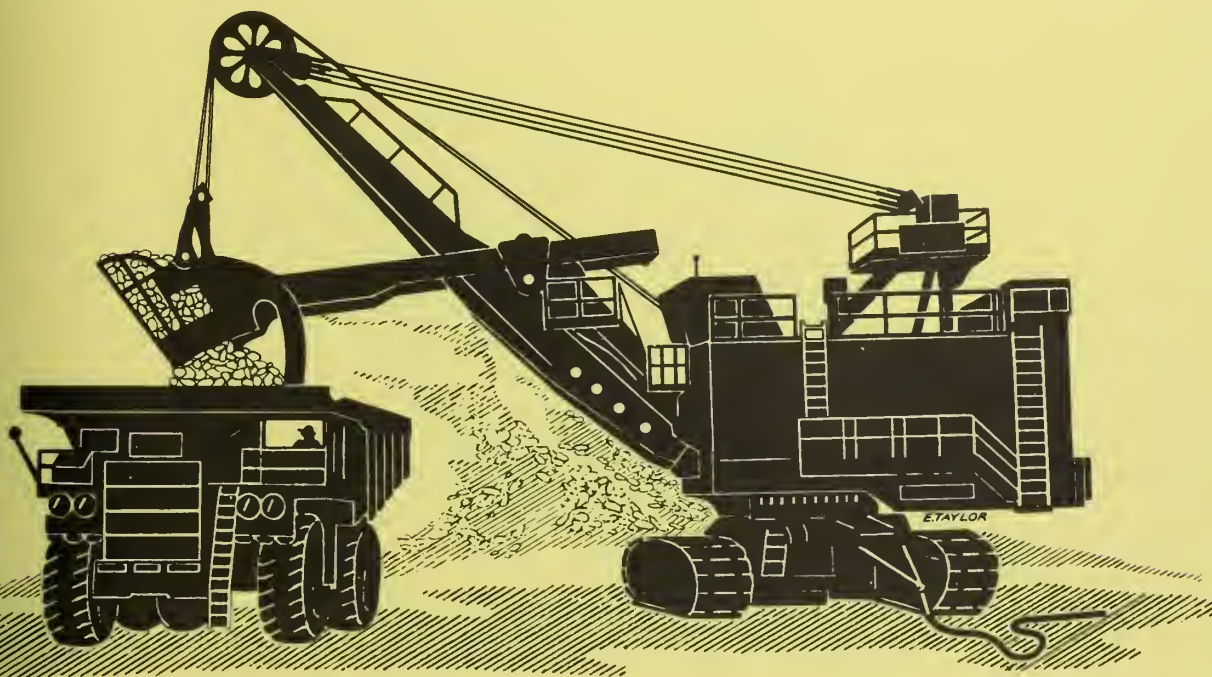


MINERAL COMMODITY REPORT

—SODIUM CARBONATE—

1985



CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY

SPECIAL PUBLICATION 83



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SPECIAL PUBLICATION 83

MINERAL COMMODITY REPORT

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By
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Part I from
the U.S. Bureau of Mines publication,
Mineral Commodity Summaries, 1984

CALIFORNIA DEPARTMENT OF CONSERVATION

DIVISION OF MINES AND GEOLOGY

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INTRODUCTION

This report on the availability and demand for sodium carbonate in the United States, the world, and California, is one of a series of Mineral Commodity Reports prepared by the Department of Conservation's Division of Mines and Geology (DMG) to describe mineral commodities of significant importance to California and the nation.

This report was compiled by Hasmukhrai H. Majmundar of the DMG geologic staff. Part I of the report consists of United States and world-wide mineral-statistic information and analysis adopted directly from the U.S. Bureau of Mines "Mineral Commodities Summaries" (1984). Part II discusses production of the commodity in California. The U.S. Bureau of Mines presents the earliest Government estimates of non-fuel mineral-industry data, including world resource data provided by the U.S. Geological Survey.

In 1983, the United States produced 8.4 million short tons of sodium carbonate, imported 0.02 million short tons, exported 1.6 million short tons, and had an apparent consumption of 6.82 million short tons of both natural and synthetic sodium carbonate. The imports were from Canada (99%) and several other countries (1%). The total estimated value of United States sodium carbonate produced in 1983 was \$675 million. Due to decreases in charges for rail and ocean transportation, exports of sodium carbonate increased to a record high level in 1983. Improvement in the world economy also stimulated increased demand for sodium carbonate. This increase was accompanied by a slight shift in the universal trade patterns. The domestic demand for sodium carbonate increased in 1983 over that of 1982. During the same period, however, the need for sodium carbonate in the glass container manufacturing industries fell because of the increased use of polyethylene terephthalate (PET) containers and cullet glass. The demand for sodium carbonate in the United States is expected to increase at an annual rate of about 1.2 percent through 1990.

More sodium carbonate (soda ash) is utilized than any other industrial chemical except salt (NaCl) and sulfuric acid (H_2SO_4). It is one of the most useful alkali reagents. More than half of the soda ash used or sold in the United States (51%) is consumed by the glass manufacture industry. Some 22 percent of all the sodium carbonate produced is used in the manufacture of chemicals including sodium phosphate, sodium silicate, sodium bicarbonate, and other sodium chemicals. The rest of the uses include manufacture of soaps and detergents (7%), pulp and paper (4%), and uses in water treatment (4%). In smaller amounts, it is also used in petroleum refining, in the treatment of certain ores, and as power-plant flue gases. In 1983, about 3,400 workers were directly employed in mines and plants in the United States.

An important and especially abundant source mineral for sodium carbonate is trona ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$). The next most abundant sodium carbonate mineral is natron ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$).

There are at least 61 identified natural sodium carbonate deposits in the world. Of these, the United States has 20, China 9, Tanzania 5, the U.S.S.R. 4, Canada and Kenya 3 each, Bolivia and India 2 each, and 1 each in Botswana, Brazil, Chad, Egypt, Ethiopia, Mexico, Namibia, Niger, Pakistan, the Republic of South Africa, Turkey, Uganda, and Venezuela.

The world's largest deposit of trona is in the Green River basin of Wyoming in the United States. This deposit contains about 62 billion tons of bedded trona and 52 billion tons of 4-feet-thick interbedded trona and halite (total of about 52 billion tons of soda ash*). Forty billion tons of halite-free trona and 27 billion tons of 6-feet-thick interbedded trona and halite (total of about 37 billion tons of soda ash) are the estimated reserves of sodium carbonate. California produces about half of the natural soda ash in the United States. This is produced from the brines of dry lakes of California. One of the world's biggest natural saline mineral accumulations lies in Searles Valley, just north of the Mojave Desert of California. Two other potential sources of soda ash are in northwest Colorado, where 32 billion tons of nahcolite (sodium bicarbonate) and 19 billion tons of dawsonite (sodium aluminum-carbonate), equivalent to 27 billion tons of sodium carbonate resources, are available as a byproduct of oil shale processing.

For further information, please call (916) 445-5716, the DMG centralized information number.

*About 1.8 tons of trona yields 1 ton of sodium carbonate.

PART I: UNITED STATES AND WORLDWIDE

1. UNITED STATES PRODUCTION AND USE

Sodium Carbonate: Five companies in Wyoming and two in California comprised the natural soda ash industry. Their combined annual nameplate capacities were about 10.7 million tons. Synthetic soda ash was produced at Syracuse, New York by one company with a 700,000-ton-per-year capacity. Sodium sulfate, potassium chloride, borax, and other minerals were produced as coproducts from sodium carbonate production in California. The total estimated value of domestic soda ash produced in 1983 was \$675 million.

Nearly 51% of the soda ash was used for manufacturing glass. The chemical industry consumed 22%; soaps and detergents, 7%; water treatment, 4%; pulp and paper, 4%; and other, 12%.

2. SALIENT STATISTICS -- UNITED STATES

Sodium Carbonate (Data in thousand short tons, unless noted):

	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983^e</u>
Production: Natural and Synthetic	8,253	8,275	8,281	7,819	8,400
Imports for consumption	40	18	12	18	20
Exports	997	1,094	1,051	1,109	1,600
Apparent consumption (natural and synthetic)	7,304	7,134	7,112	6,667	6,824
Prices: Quoted, soda ash, natural, dense, bulk, f.o.b. Green River, Wyo., dollars per ton	\$76.00	\$86.00	\$92.00	\$84.00	\$84.69
f.o.b. Searles Valley, Calif. same basis	\$77.25	\$90.25	\$106.25	\$107.25	\$103.00
f.o.b. Syracuse, N.Y., synthetic, same basis	\$96.00	\$112.00	\$132.00	\$132.00	\$132.00
Average sales value (natural sources), f.o.b. mine or plant, dollars per ton	\$64.55	\$89.85	\$91.19	\$88.35	\$80.00
Producer stock at yearend	68	133	263	324	320
Employment: Mine and plant	3,600	3,600	3,650	3,300	3,400
Net import reliance ¹ as a percent of apparent consumption					
				Net	exporter

^e Estimated.

¹ Defined as imports-exports + adjustments for Government and industry stock changes.

Prepared by D.S. Kostick, telephone number (202) 634-1177.

3. RECYCLING

There is no recycling of soda ash by producers; however, container glass producers are using cullet glass, thereby reducing soda ash consumption.

4. IMPORT SOURCES (1979-82)

Canada 99%, Other 1%.

5. TARIFF

<u>Item</u>	<u>Number</u>	<u>Most Favored Nation (MFN)</u>		<u>Non-MFN</u>
		<u>1/1/84</u>	<u>1/1/87</u>	<u>1/1/84</u>
Calcined (soda ash)	420.84	1.2% ad val.	1.2% ad val.	8.5% ad val.
Hydrated and sesquicarbonate	420.86	0.2 ¢/lb.	0.1 ¢/lb.	0.25 ¢/lb.

6. DEPLETION ALLOWANCES

14% (Domestic), 14% (Foreign). For natural only.

7. GOVERNMENT STOCKPILE

None.

8. EVENTS, TRENDS, AND ISSUES

The Canadian Department of National Revenue, Customs, and Excise ruled that six U.S. soda ash producers were guilty of dumping dense soda ash on the Canadian market in 1982. The case was referred to the Anti-Dumping Tribunal to determine what duties would be levied on the U.S. soda ash industry, but the final decision was pending by yearend.

Two companies formed a joint venture with the intent to solution mine one million tons of nahcolite (natural sodium bicarbonate) that is associated with oil shale near Rifle, Colorado. Solution-mining tests were conducted at midyear to determine the technical feasibility of the project. Nahcolite could be used as an effective sulfur removal agent in stack gas scrubbing and also could be converted to soda ash.

The U.S. Bureau of Land Management sought comments on a proposed sodium concessionary leasing process for Wyoming trona. If approved, the proposed process would improve competition for sodium lease sales and streamline government leasing procedures.

Exports of soda ash increased to a record high level in 1983 because of favorable rail and ocean transportation rates, an improvement in the world economy that stimulated soda ash demand, and a slight shift in global trade patterns. Total domestic demand for soda ash increased compared with that of 1982; however, demand for soda ash to produce glass containers, which has historically represented the largest end use of soda ash, decreased because of competition from polyethylene terephthalate (PET) containers and cullet glass.

From a 1980 base, demand for soda ash is expected to increase at an annual rate of about 1.2% through 1990. It is estimated that in 1984 domestic mine production of sodium carbonate will be 8.5 million tons and the U.S. apparent consumption will be 7.0 million tons.

9. WORLD MINE PRODUCTION AND RESERVE BASE (NATURAL SOURCES)

	<u>Mine Production</u>		<u>Reserve Base*2</u>
	<u>1982</u>	<u>1983^e</u>	
United States (includes synthetic)	7,819	8,400	42,700,000 ³
Botswana	NA	NA	400,000
Chad	6	6	8,000
Kenya	330	290	56,000
Uganda	NA	NA	18,000
World Total	<u>8,200⁴</u>	<u>8,700⁴</u>	<u>43,200,000</u>
(may be rounded)			

10. WORLD RESOURCES

Soda ash was obtained from trona and sodium carbonate-rich brines. The world's largest deposit of trona is in the Green River Basin of Wyoming. About 52 billion tons of identified soda ash resources could be obtained from the 62 billion tons of bedded trona² and the 52 billion tons of interbedded or intermixed trona and halite that are in beds more than 4 feet thick. About 37 billion tons of reserve base soda ash could be obtained from the 40 billion tons of halite-free trona and the 27 billion tons of interbedded or intermixed trona and halite that are in beds more than 6 feet thick. Two potential sources of soda ash, nahcolite (sodium

* Pending establishment of criteria for the reserve base, classification of data is based on a judgmental appraisal of current knowledge and assumptions. NA = Not available.

2 The reported quantities are sodium carbonate only. About 1.8 tons of trona yield 1 ton of sodium carbonate.

3 From trona, nahcolite, and dawsonite sources.

4 Does not include Botswana and Uganda.

bicarbonate), and dawsonite (sodium aluminum-carbonate) are associated with oil shale in northwest Colorado. Identified resources of 32 billion tons of nahcolite and 19 billion tons of dawsonite (equivalent to 27 billion tons of sodium carbonate resources) are available as a byproduct of oil shale processing.

There are at least 61 identified natural sodium carbonate deposits in the world, some of which have been quantified. The countries and number of deposits include: Bolivia (2), Botswana (1), Brazil (1), Canada (3), Chad (1), China (9), Egypt (1), Ethiopia (1), India (2), Kenya (3), Mexico (1), Namibia (1), Niger (1), Pakistan (1), the Republic of South Africa (1), Tanzania (5), Turkey (1), Uganda (1), the U.S.S.R. (4), the United States (20), and Venezuela (1).

11. SUBSTITUTES

Caustic soda can be substituted for soda ash in certain uses. An alternate source of soda ash is nahcolite, but commercial development of oil shale mining with byproduct nahcolite and dawsonite recovery is uncertain.

PART II: CALIFORNIA

12. CALIFORNIA GEOLOGICAL AND MINERAL OCCURRENCES

Sodium carbonate is called soda ash in the commercial field. About half of the natural soda ash produced in the United States comes from California. The rest comes from operations in Wyoming. There was a time when only 10% of the soda ash used in the United States was natural and 90% was synthetic (Ver Planck, 1957). Figure 1 shows clearly that natural soda ash is replacing the synthetic soda ash production.

Sodium carbonate is produced from the brines of certain springs and saline lakes, and also from deposits formed by evaporation of sodium carbonate brines. Trona ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$) is the most common sodium carbonate mineral. It is a very soluble, gray to yellowish, translucent, fibrous or columnar, cleavable to massive mineral. Natron ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$) is the next most abundant sodium carbonate mineral. It is also very soft and dehydrates on exposure to dry air. Other sodium carbonate minerals that occur in California include: burkeite ($2\text{Na}_2\text{SO}_4 \cdot \text{Na}_2\text{CO}_3$), gaylussite ($\text{Na}_2\text{CO}_3 \cdot \text{CaCO}_3 \cdot 5\text{H}_2\text{O}$), Hanksite ($9\text{Na}_2\text{SO}_4 \cdot 2\text{Na}_2\text{CO}_3 \cdot \text{KCl}$), northupite ($\text{Na}_2\text{CO}_3 \cdot \text{MgCO}_3 \cdot \text{NaCl}$), pirssonite ($\text{Na}_2\text{CO}_3 \cdot \text{CaCO}_3 \cdot 2\text{H}_2\text{O}$) and thermonatrite ($\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$) (Smith and others, 1983). The sodium bicarbonate mineral, nahcolite (NaHCO_3) also occurs in California. All these sodium carbonate minerals are present in the brines of dry lakes in California.

The only other deposit of sodium carbonate minerals being worked in the United States is near Green River, Wyoming.

13. CALIFORNIA LOCALITIES

All the sodium carbonate produced in California comes from the brines of Searles and Owens Lakes. The Kerr-McGee Chemical Corporation's plants in Argus and Westend in Searles Dry Lake in San Bernardino County, and Lake Minerals Corporation's workings in Owens Dry Lake in Inyo County produce the total soda ash in California.

One of the world's biggest natural saline mineral accumulations lies in Searles Valley, just north of the Mojave Desert of California. To gain this mineral wealth, Searles Valley has gone through a unique geologic past. About three million years ago, the Sierra Nevada range started its uplift. The mountains acted as a rain barrier between the Pacific and the interior land. The Owens, Indian Wells, Searles, Panamint, and Death valleys are in the rain-shadow regions. Hence, the climate became more arid. During the periods of recession of the ice ages, water from melting snow and rains rushed down the eastern slopes of the Sierra Nevada into the basins below and overflowed from one to the next until a chain of five lakes was formed extending from Owens Valley to Death Valley. This water picked up tremendous quantities of sand, silt, and dissolved minerals. On their course to lower elevations, the flood waters filled Owens Valley and spilled into the flat terrain at Indian Wells, where

Natural Soda Ash Is Replacing Synthetic Production

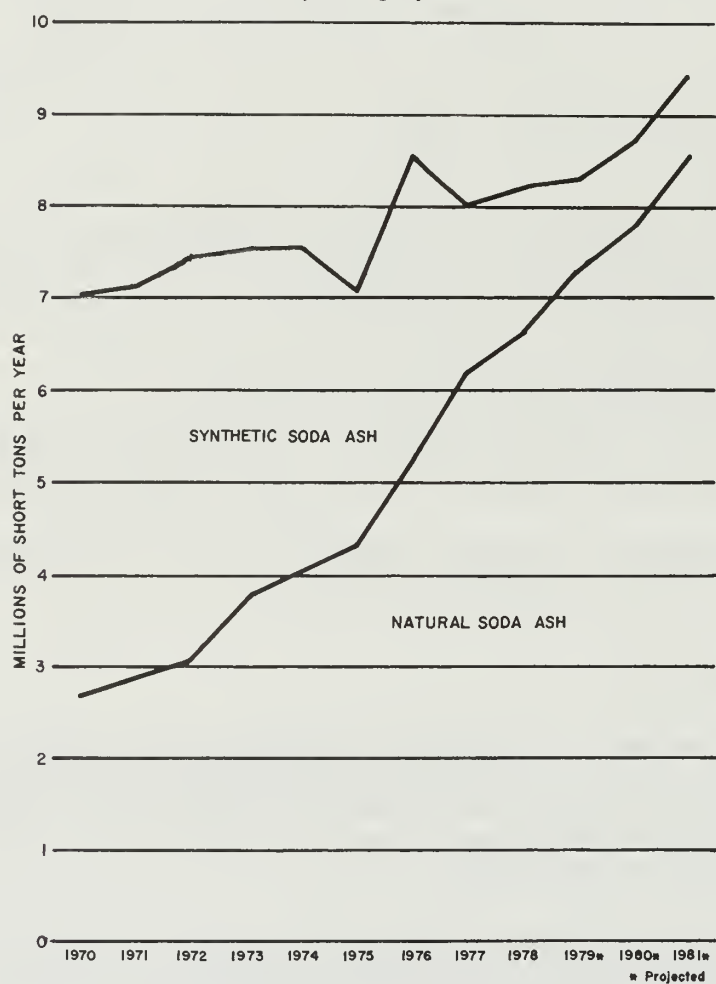


Figure 1. Natural soda ash is replacing synthetic production (after Kerr-McGee Chemical Corporation Bulletin 1400).

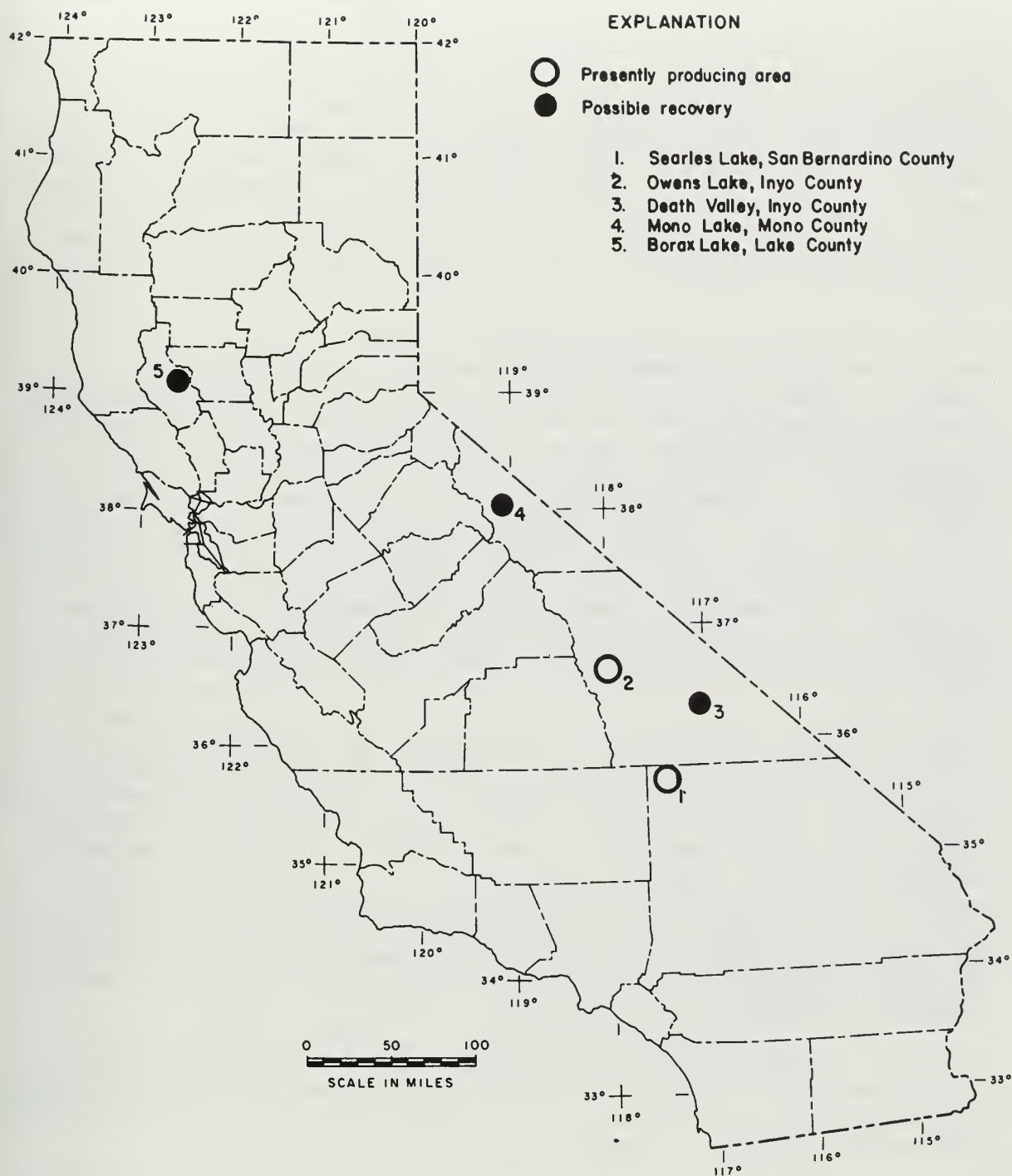


Figure 2. Soda ash deposits in California.

sand and silt were deposited, while most of the soluble minerals flowed into the Searles Valley. There were two such great water flows during the recession stage of two glaciation periods. Between these two periods were the intermittent periods of intensive evaporation under the desert sun, during which the dissolved salts concentrated in Searles Valley. Eventually, the waters became saturated and crystallization of the salts occurred. Searles Lake bed was left as it is today, with distinct salt layers separated by mud beds. The lake in Searles Valley reached a depth of about 650 feet and covered almost 400 square miles. This large area was reduced to its present 30 square miles extent and average depth of over 150 feet, leaving a deposit of about 3 billion tons of soluble mineral salts. The first 60 to 100 feet of crystallized material yields a dense, alkaline brine containing 98 of the 104 known chemical elements (Adams, 1982).

Searles Lake's major minerals include borax, soda ash, salt cake, tungston, lithium, and potash. The brines in Searles Lake are pumped out from two stratigraphic units known as the Lower Salt and Upper Salt beds. The thickness of the Lower Salt bed ranges from about 39 feet in the center of the lake to zero at the periphery of the lake. This bed occupies an area of about 40 square miles in the lowest part of Searles Valley. This unit is composed of seven saline layers interbedded with mud layers. The saline layers principally consist of trona. The thickness of the Upper Salt bed ranges from 75 feet at the lake center to zero at its periphery. The lower brine contains 6.78 percent sodium carbonate and the upper brine 4.80 percent sodium carbonate. Below these two salt beds, there is an older stratigraphic unit (see Figure 3) that contains a series of mud and saline beds. This unit is known as the Mixed-Layer Zone.

The lateral and vertical extent of these beds are not fully known. The upper part of the Mixed-Layer Zone is divided into three subunits (A, B, and C zones) based on electrical conductivity tests; and the lower part is divided into three subunits (D, E, and F zones) on the basis of mineral composition. The A zone brine is low in chloride and high in carbonate; Kerr-McGee Chemical Corporation pumps out this brine from the A and B zones at their Argus facility along with brines from the Lower Salt bed and the Upper Salt bed. More important commercially, the void space in the salt beds is filled with brine. This brine serves as today's source of sodium, potassium, borate, and other recoverable minerals at Searles Lake.

Principal components of natural soda ash sources from Searles Lake and Wyoming are given in Table 1. The mining operations and recovery of salts in Searles Lake involve scraping the dry lake surface. The solid salts in Searles Lake have been virtually untouched!

Kerr-McGee Chemical Corporation pumps out brine from both Upper and Lower Salt beds in their Westend plant. In their Trona plant, they pump out brine from both Upper and Lower salt beds: the main plant uses brine from Upper and Lower Salt beds and the boric acid plant uses brine primarily from the Lower Salt bed.

The Owens Dry Lake has similar saline beds except that they are thinner, only 9 feet thick, and the brine contains sodium carbonate ranging from 11.98% in the winter to 16.62% in summer.

The brines of Mono Lake in Mono County and Borax Lake in Lake County also contain sodium carbonate that deposits trona upon evaporation. The brines of Mono Lake are far below saturation, and the deposit is far from the soda ash markets. Borax Lake is small, consisting of 200-300 acres only, with estimated reserves of about 23,000 tons of sodium carbonate (Averill, 1947).

TABLE 1

PRINCIPAL COMPONENTS OF NATURAL SODA ASH SOURCES

Components	Approximate Percent Composition	
	Searles Lake Brine*	Wyoming trona ore**
Carbonate as Na_2CO_3	6	45
Bicarbonate as NaHCO_3	less than 0.1	36
Chloride as NaCl	16	0.04
Potassium as KCl	4	—
Sulfate as Na_2SO_4	6	0.01
Borate as $\text{Na}_2\text{B}_4\text{O}_7$	2	—
Sulfide as Na_2S	0.2	—
Phosphate as Na_3PO_4	0.1	—
Iron as Fe_2O_3	—	0.08
Water insoluble	—	3.6
Water	65.6	15.3

* Average of upper and lower structure brines.

** The ore contains the mineral trona, a hydrated double salt of sodium carbonate and sodium bicarbonate, $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$. Principal locations of trona are in the crystalline solids at Searles Lake and bedded deposits in Wyoming.

Efflorescent crusts containing trona and thermonatrite occur in the floor of Death Valley and on the margins of many playas. One deposit of this type on the east side of Searles Lake is the reef consisting of less than 50 percent of the mineral trona. Hence, the name of the town is given as Trona. Such deposits are too small and too low in sodium carbonate content for commercial development, and have not been worked in California.

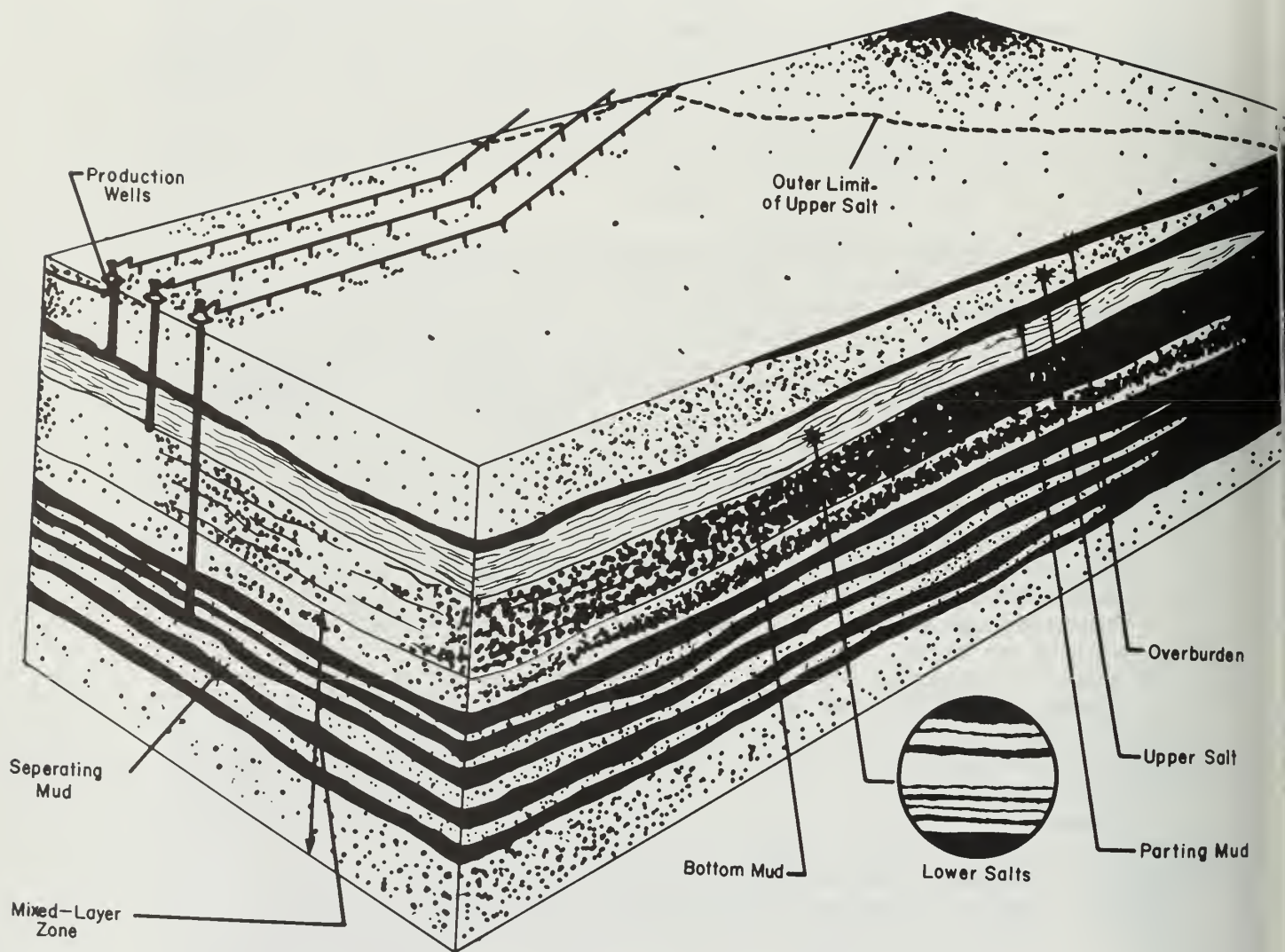


Figure 3. Block diagram of various salt beds in Searles Valley area (after Adams, 1982).

14. CALIFORNIA PRODUCTION

In California, there are total of three facilities producing sodium carbonate from the dry lake brines. Two of the facilities are the Argus and the Westend plants of the Kerr-McGee Chemical Corporation in Searles Valley. These two facilities manufacture sodium carbonate from the brine. The third facility is in Owens Valley, owned and operated by Lake Minerals Corporation, a subsidiary of Cominco American, Inc., and it produces raw trona ore. The production figures for all three facilities are confidential and hence cannot be given here. A published article indicates the design capacity of the Argus facility to be 1.3 million tons per year of soda ash. This capacity is reported to be more than four times the combined soda ash production of the other two Kerr-McGee plants. When the Argus facility is completely operational, and with phasing out of the old soda ash production units at Trona, Kerr-McGee will have a combined annual capacity of 1.45 million tons of soda ash.

Soda ash from the Argus and Westend plants of the Kerr-McGee Chemical Corporation in Searles Valley is (a) sent to all the western states including California; (b) shipped to glass-manufacturing plants on the East Coast via the Panama Canal from Long Beach Harbor, which is only 180 miles southwest of Searles Valley; and (c) shipped to the Far East and Central and South American countries. The worldwide demand for sodium carbonate is increasing, and thus the future of Kerr-McGee's new facility at Argus, which only produces soda ash, is very solid. The Lake Minerals Corporation's Owens Valley plant produces raw trona ore, all of which is supplied to U.S. Borax and Chemical Corporation at Boron for use as a reagent to manufacture borates.

15. UTILIZATION AND MARKETS

Soda ash is used in larger quantity than any other industrial chemical except salt (NaCl) and sulfuric acid (H_2SO_4). It is one of the most useful alkali reagents. Over and above its principal use, it is also used in the manufacture of other sodium compounds as a base reagent. The reason for this is that sodium carbonate is relatively cheap and easily reacts with most other chemicals. For most purposes, sodium carbonate has no substitute, except for some special uses, where caustic soda (NaOH) is used as a substitute. In such cases, sodium carbonate is causticized before use.

The biggest use for sodium carbonate is for glass manufacture (51%). The next biggest use is in chemical manufacturing (22%). Other uses include soaps and detergents manufacturing (7%), water treatment (4%), pulp and paper industries (4%), and other miscellaneous (12%). The chemical manufacturing include sodium phosphate manufacturing (51%), sodium silicate manufacturing (22%), miscellaneous chemical manufacturing (15%), sodium bicarbonate manufacturing (8%), and miscellaneous sodium chemical manufacturing (4%). It is also used in small amounts in petroleum refining and in the treatment of certain ores.

Sodium bicarbonate (Nahcolite) is used directly in a totally dry system to remove SO_2 from industrial and power-plant flue gases. Sodium bicarbonate reacts with SO_2 to give dry sodium sulfate, which can be removed with the fly ash and buried in watertight disposal areas.

Markets served by sodium carbonate are glass manufacturing industries, chemical manufacturing industries -- including sodium compound manufacturing plants, soap and detergent industries, pulp and paper industries, water softening plants, ore dressing plants, and oil refineries. Sodium carbonate is a comparatively inexpensive commodity. Freight charges make up a significant portion of the cost which the consumer pays. Therefore, most of the plants using sodium carbonate appear to be near the source of soda ash plants.

The Kerr-McGee Chemical Corporation employs more than 1,000 employees (Whorley, 1984) in the three plants in the Searles Lake area. The Lake Minerals Corporation employs eight employees (Lamos, 1984) in its Owens Lake facility.

16. MINING METHODS AND BENEFICIATION

Almost all sodium carbonate brines present in California are of a complex nature, and contain high proportions of contaminants like sulfate, chloride, borate along with the carbonate. Therefore, production of chemical-grade sodium carbonate from such brines is a difficult task. Solar evaporation is one of the methods used for unsaturated brines. In earlier days, trona was obtained by evaporation and was calcined to produce soda ash of about 95 percent purity. The solar evaporation of saturated brines gives rise to a mixture of complex salts that cannot be separated easily. The brines of Searles and Owens Lakes are saturated brines. The brine is pumped out and passed through the heat exchangers that warm the liquid to about 135°F . Then the liquid is passed through the carbonating units. During the carbonation process, the carbon dioxide reacts with the hot brine and forms sodium bicarbonate, commonly known as baking soda. When the carbonated brine cools, additional sodium bicarbonate crystallizes. Then the brine is passed through filters to remove solids. The liquid at this stage is returned to the lake. The sodium bicarbonate from the filters is passed through the rotary dryers, which causes some of the water from the sodium bicarbonate to evaporate. The water-free sodium bicarbonate is passed through a second set of dryers operating at about 450°F . This heat cracks free a molecule of carbon dioxide, and thus produces sodium carbonate from the sodium bicarbonate. Natural gas-fired bleachers burn off combustible impurities. The last step is the removal of salt and any other impurities from this hot sodium carbonate by the process of recrystallization.

The Argus facility of Kerr-McGee Chemical Corporation utilizes brines pumped at the rate of more than 8,000 gallons per minute from 38 wells. It is the biggest soda ash plant in the country. In the control room of this plant, two technicians constantly monitor a 27-foot-long operating board that indicates the operation of each processing step. They look

after all the control for hundreds of pumps and motors with 108 automatic valves. Any change in processing affects the next step in the chain of processing. Control room technicians rely on two-way radios to contact any of the 17 field technicians who keep a close check on the whole plant. The power generating plant at Argus is California's first coal-fired generating plant equipped with air pollution control equipment costing more than \$23 million. Kerr-McGee Corporation boasts that emissions from this plant in Searles Valley are cleaner than federal regulations require. Each day, the furnaces burn the equivalent of 12 rail cars of coal and petroleum coke, while each boiler requires 1,200 gallons of water per minute. According to the company, the boiler feed water contains 400 times less dissolved solids than the drinking water. This power plant can supply the electrical needs of 60,000 average homes.

The first synthetic sodium carbonate was made by the LeBlanc process, invented by the French chemist Nicholas LeBlanc in 1791. In this process, salt (NaCl) is treated with sulfuric acid to produce sodium sulfate. This sodium sulfate is then reduced to sodium sulfide by heating with carbon (from charcoal, coal, or coke). The sodium sulfide is then reacted with limestone, which produces sodium carbonate. This process can not be utilized economically under the present federal and state air pollution restrictions and the current fuel costs.

Synthetic sodium carbonate is now manufactured from common salt by the ammonia-soda or Solvay process, which was perfected by Ernest Solvay in 1861. This process consists of treating salt brines (NaCl brines) with ammonium bicarbonate to precipitate sodium bicarbonate and then sodium bicarbonate is calcined to sodium carbonate. Carbon dioxide is the byproduct of the calcination process, which is recycled with ammonia to regenerate ammonium bicarbonate. This process also generates calcium chloride as a byproduct.

17. CALIFORNIA EVENTS, TRENDS AND ISSUES

In 1978, the Kerr-McGee Chemical Corporation completed the construction of its newest and most modern soda ash plant at Argus. This plant is the biggest soda ash plant in the country. At the end of the first year, this plant had produced 900,000 tons of soda ash. Production is expected to increase to 1.3 million tons per year at full capacity. As stated in Section 8, from a 1980 base, demand for soda has been increasing. Thus, the world-wide demand for soda ash will anchor a solid future for this plant.

Recovery of the solid salts in Searles Lake involves the relatively simple process of scraping the surface of the lake. This preserves the tremendous resources of solid salts for the future for any greater demand that the world might have.

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